

**PROBE FOR ELECTRICAL MEASUREMENT METHODS, ESPECIALLY EDDY  
CURRENT MEASUREMENTS****CROSS REFERENCE TO RELATED APPLICATION**

[0001] This application is the US National Stage of International Application No. PCT/EP2004/006792, filed June 23, 2004 and claims the benefit thereof. The International Application claims the benefits of European Patent application No. 03015494.2 EP filed July 09, 2003, both of the applications are incorporated by reference herein in their entirety.

**FIELD OF THE INVENTION**

[0002] The invention is based on a probe for electrical measurement methods according to the claims.

**BACKGROUND OF THE INVENTION**

[0003] DE 197 48 556 A1 discloses a probe for an eddy current measurement with a ferromagnetic signal amplification, the signal amplification being produced by a rigid ferritic core. With a probe formed by a rigid substrate on which planar coils are mounted, test pieces with a planar surface can be measured. In the case of non-planar surfaces, the probe must be adapted in its shape to a surface of the test piece; otherwise, incorrect measured values are obtained.

[0004] A probe with eddy current measurement with ferromagnetic signal amplification for planar test pieces is also known from US Patent 6,002,251.

[0005] US Patent 5,389,876 discloses a probe for an eddy current measurement, which however produces only weak signals.

**SUMMARY OF THE INVENTION**

[0006] The object of the invention is therefore to present a probe for electrical measurement methods which can be used for variously curved surfaces of the test piece.

[0007] The object is achieved by the probe with the substrate being formed permanently elastically.

[0008] Further advantageous refinements of the probe according to the invention are mentioned in the subclaims.

[0009] The probe can be adapted to radii of curvature of, for example, 50 mm or greater.

[0010] The flexibility is advantageously achieved by a substrate that is formed by a flexible film being used for the probe, advantageously polyimide.

[0011] For example, two coils, especially planar coils, especially of copper, are advantageously mounted on the flexible film as electrical components.

[0012] The flexibility of the probe is also maintained by a permanently elastic backing of the electrical components.

[0013] A polymer film which is filled with a ferrite is advantageously used for the backing, so that a ferromagnetic signal amplification is advantageously possible.

[0014] Similarly, thin flexible sheets of ferrite may be used.

[0015] A casting compound with ferrite particles, the casting compound being permanently elastically deformable, may also be used here.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0016] Exemplary embodiments of the invention are represented in a simplified and schematic form in the drawings, in which:

Figure 1 shows an arrangement of an exciter and a signal coil,

Figure 2 shows a first exemplary embodiment of a probe according to the invention, and

Figure 3 shows a further exemplary embodiment of a probe formed according to the invention.

#### DETAILED DESCRIPTION OF THE INVENTION

[0017] Figure 1 shows an exciter coil 4 and a signal coil 7 as electrical components in their arrangement in one plane according to the prior art.

[0018] The signal coil 7 is, for example, surrounded by the exciter coil 4. With respect to the further exemplary construction of the exciter coil 4, signal coil 7 and an evaluation system with a probe, reference is made to DE 197 48 556 A1, which is expressly intended to form part of this disclosure.

[0019] The exciter coil 4 and signal coil 7 are electrically separated from each other. The signal coil 7 is in this example designed as a differential probe. The local resolution is determined by the distance between the the two coil sections, the so-called baseline.

[0020] The exciter winding 4 encloses the coil sections of the signal coil 7, for example symmetrically, so that a compensation of the exciter field is ensured. The exciter winding 4 and the signal coil 7 consequently lie in one plane or on the same surface of the substrate 16. Exemplary embodiments of probes are:

[0021] An XXL probe has a baseline of 3.3 mm, an exciter coil with 21 windings and a signal coil with 8 windings.

[0022] An S probe has a baseline of 2.3 mm, an exciter coil with 9 windings and a signal coil with 5 windings.

[0023] A probe, which comprises, inter alia, the exciter coil 4 and signal coil 7, is moved in a scanning direction 13, identified by an arrow, over a surface of a test piece 10 (indicated by a dashed outline), the probe 1 coming to rest on the test piece 10 with a resting surface 37 (Figure 2). The test piece 10 contains defects, for example in the form of cracks, which influence a magnetic signal of the exciter coil 4, whereby the defects in the interior of the test piece 10 and on its surface can be established.

[0024] Figure 2 shows a first exemplary embodiment of a probe 1 for electrical measurement methods according to the present invention. A film, which is flexible and, for example, also elastic, especially permanently elastic, is used for example as the substrate 16, which rests directly on the test piece. A polyimide film is preferably used.

[0025] Permanent elasticity means that the mechanical elasticity is maintained at least over the service life of the probe 1. On the substrate 16, the exciter coil 4 and the signal coil 7 are arranged, for example, in a planar manner, i.e. the coil comprises only one

conductor track which runs only in one plane. The coils 4, 7, as electrical components, may be mounted on the film 16 by means of a galvanic process or a wet-chemical process.

[0026] On the substrate 16 and on or around the coil 4, 7, there is applied for example, but not necessarily, an adhesive 19, which bonds the backing 22 to the substrate 16.

[0027] The backing 22 is of an elastic, especially permanently elastic, form.

[0028] Preferably used as the material for the backing 22 is a ferritic and/or other magnetic (ferromagnetic, strongly paramagnetic) material for signal amplification, in particular for ferromagnetic signal amplification, for example with a permeability  $\mu$  of up to 100. Leading through the backing 22 there is, for example, at least one electrical lead 31 for the coil 4, 7 for a measuring system according to DE 197 48 556 A1.

[0029] An elastic, especially permanently elastic, casting compound filled with ferrite particles or a gas-filled material, in particular plastic or rubber, may be used as the backing 22.

[0030] The polyimide film 16 has, for example, a thickness of 25  $\mu\text{m}$ , the copper coil has a thickness of 17  $\mu\text{m}$ , the adhesive extends over a thickness of about 30  $\mu\text{m}$ , and the polymer film filled with ferrite extends over a thickness of 200 - 600  $\mu\text{m}$ .

[0031] This stack of layers comprising the substrate 16 and the backing 22 remains sufficiently flexible, so that the stack of layers can adapt itself without any problem to different radii of curvature of the test piece 10 of, for example, 50 mm or more.

[0032] Figure 3 shows a further exemplary embodiment of a planar probe 1 formed according to the invention.

[0033] The backing 22 may also be ensured by a casting material 34, in which ferrite powder is mixed. The average diameter of the ferrite particles is, for example, about 10  $\mu\text{m}$ . The casting compound is elastically, especially permanently elastically, deformable, and remains so after a curing process, so that a flexibility of the probe 1 is permanently ensured.

**[0034]** The probe 1 is made to be of such a size that it covers the entire region to be examined of the test piece 10, for example a trough, as represented for example in Figure 3, so that the region to be examined is examined in one scan, that is by moving the probe 1 once.

**[0035]** Such troughs occur for example in the case of blade roots of a fir-tree-shaped turbine blade.

**[0036]** As electrical measurement methods, the probe 1, which has two coils 4, 7 or only one coil and a ferromagnetic signal amplification 22, can be used for eddy current measurement, which serves, for example, the purpose of detecting defects on metallic components 10.